City of Lincoln's *Drainage Criteria Manual*. Regional detention facilities that control runoff from entire developments or large portions of catchments (tributary areas of approximately 100 acres or larger) are generally more effective than on-site facilities that control runoff from only one site (tributary areas as small as a few acres). Regional detention facilities are often designed and constructed with greater care and have better long-term maintenance. If properly designed and constructed, storage facilities reduce to historic levels the peak flow rates from a new development at the location immediately downstream of the outlet structure of the storage facility. The hydrology of the catchment downstream of the facility is nevertheless changed because the volume of runoff is increased. Without a regional watershed plan, this increase in volume from each sub-catchment will likely increase the overall peak flow rate in the stream further downstream in the watershed (as the flows from several catchments combine). The effect of detention should be included in the hydrologic modeling of the watershed so that channel improvements can be properly designed.

Channel improvements must focus upon establishing a stable longitudinal bed slope for the stream channels in the study area. This can be done a variety of ways. If a constructed channel is proposed for a given reach of stream, the slope of the channel must be stable for the bed material used. Drop structures should be used to reduce the slope of the constructed channel from the original channel slope. Wetland bottom channels and grassed channels are preferred over hard-lined channels. Channel stability and habitat can be enhanced by providing for a wide buffer zone around the channel and providing a sinuous, meandering invert for the low-flow channel. Channel improvements can provide for improved habitat by including pools and bed material preferred by micro-invertebrates and by planting species of vegetation that provide good habitat.

If no constructed channel is provided in a reach of stream, bed stabilization should be provided. Construction of this modified natural channel can be accomplished in a number of ways. Placing buried concrete cut-off walls that will act as channel check structures would stabilize the channel bed. It may be possible to use road crossings as the primary means of maintaining a stable bed slope. This would require that each road crossing be designed as a channel check structure

(through use of a headwall with a footing well below the ground surface) and placed at the correct elevation for the future channel slope. A wide vegetated buffer zone should be provided around natural channels.

The timing and funding of channel improvements may be an issue during development of the watershed. While a developer may fund improvements to the reach of channel included within his development, the development will likely also affect downstream reaches of the stream channel. The downstream channel may be in an area that has not been developed and hence has not received any improvements. The channel could then be degraded by upstream development even though the upstream development provided detention per City of Lincoln's criteria and has stabilized the channel within its boundaries.

A system to monitor changes in the channel bed elevation and channel cross section shape would be useful in order to determine if specific reaches of the channel are influenced by upstream development.

A summary of recommended improvements for each catchment is provided below.

1. ***Catchment S-1.*** This catchment is directly tributary to Salt Creek. The majority of this catchment is currently undergoing development. Changes in hydrology from this development will only affect the channels within the catchment itself. They will not have a significant effect on downstream areas. The master planning effort should focus on ensuring that the planned drainage improvements maintain a stable channel within the catchment and the development or redevelopment meets applicable criteria.

2. ***Catchment S-2.*** This catchment lies downstream of catchment S-3 but will not be significantly affected by that catchment, unless widespread land use changes occur in the future, because S-3 is mostly built out with low-density residential development. The stream channel between 27th and 40th Streets currently shows mild degradation in some areas. The degradation of the channel will increase with development of the S-2 catchment. The channel should be monitored to determine whether it is degrading due to

development in the watershed. The channel should be stabilized with bed stabilization measures when the monitoring shows that problems are developing. A buffer area adjacent to the channel should be maintained, enlarged or provided, depending on the current condition of the riparian area.

3. ***Catchment S-3.*** This catchment is largely developed. Detention should be provided in areas that will undergo future development. Consideration should be given to retrofitting storage in the existing developments. Hydrologic analyses should be carried out to determine whether retrofitting storage facilities will produce downstream benefits. The channels in this catchment appear to be largely in good condition and may not need stabilization measures.

4. ***Catchment N-1.*** This catchment consists of a number of sub-catchments that are directly tributary to Salt Creek. The channel that flows near the Interstate 80/U.S. 77 highway intersection has been modified by area development and should be reestablished. The sub-catchments lying east of U.S. 77 appear to be in reasonably good condition south of Interstate 80. The Salt Creek floodplain dominates the southern portion of the catchment. Channel stability in this area will likely not be a significant issue, because the channel slopes are relatively flat.

5. ***Catchments N-2, N-3 and N-5.*** These catchments are all dominated by agricultural development. The creek channels in these catchments show moderate to serious degradation. Little Salt Creek through this area has degraded because of historic channelization of the channel in the reach upstream of Interstate 80 and down cutting to match Salt Creek's channel. This section of channel is straight and deep with steep, unstable banks. North of Bluff Street, the channel is more natural and less degraded. The tributaries in these catchments show incision that is progressing upstream from Little Salt Creek or, in some instances, is progressing upstream from culverts placed at too low elevations. Channel bed stabilization is essential for these catchments. Little Salt Creek may be at or near a stable slope and, consequently, not need stabilization. The resulting

drop in groundwater levels affects the saline groundwater inflow to the adjacent saline wetlands.

6. ***Catchment N-4.*** The channels in the N-4 catchment show less degradation than the channels in the other N- catchments. Some areas show deposition of materials rather than the erosion shown in the other N- catchments. The channels in this catchment should be monitored, and bed stabilization should be provided if the channels start degrading as development occurs.

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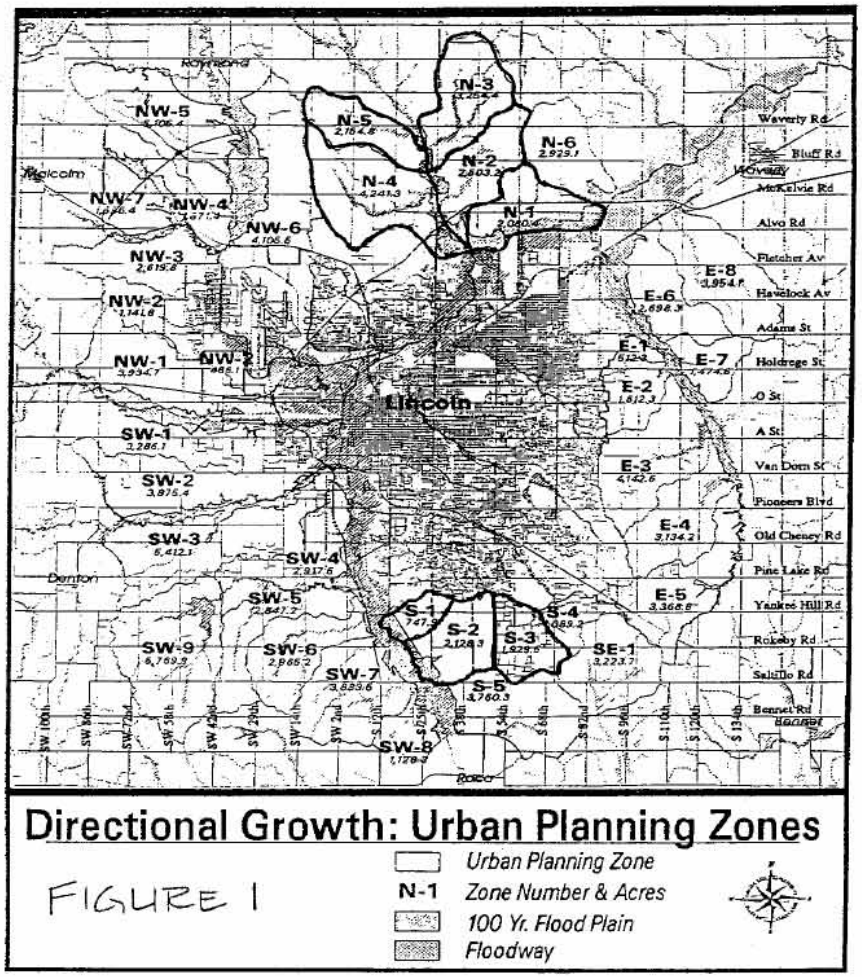

FIGURE 1

APPENDIX A

Sampling Results